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Agrama

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(54) **FACIAL MOVEMENT MEASUREMENT AND STIMULATION APPARATUS AND METHOD**

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(22) Filed: **Jul. 23, 2013**

Related U.S. Application Data

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(51) **Int. Cl.**

G06F 3/01	(2006.01)
A61N 1/04	(2006.01)
A63F 13/20	(2014.01)

(52) **U.S. Cl.**
CPC ***G06F 3/012*** (2013.01); ***A61N 1/0452*** (2013.01); ***A63F 13/06*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/01; G06F 3/012; G06F 1/163; A61N 1/04; A61N 1/0452; A63F 13/06; A63F 13/10
See application file for complete search history.

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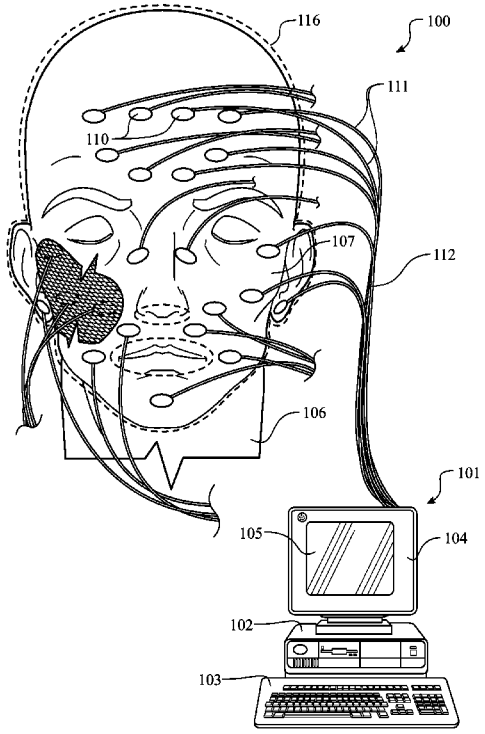
(57) **ABSTRACT**

An illustrative embodiment of a facial movement measurement and stimulation apparatus includes at least one facial movement sensor adapted to sense facial movement in a subject and a wearable computing device interfacing with the facial movement sensor or sensors and adapted to receive at least one signal from the facial movement sensor or sensors and indicate facial movement of the subject on a display of the wearable computing device. A facial movement measurement and stimulation method utilizing the wearable computing device is also disclosed.

16 Claims, 14 Drawing Sheets



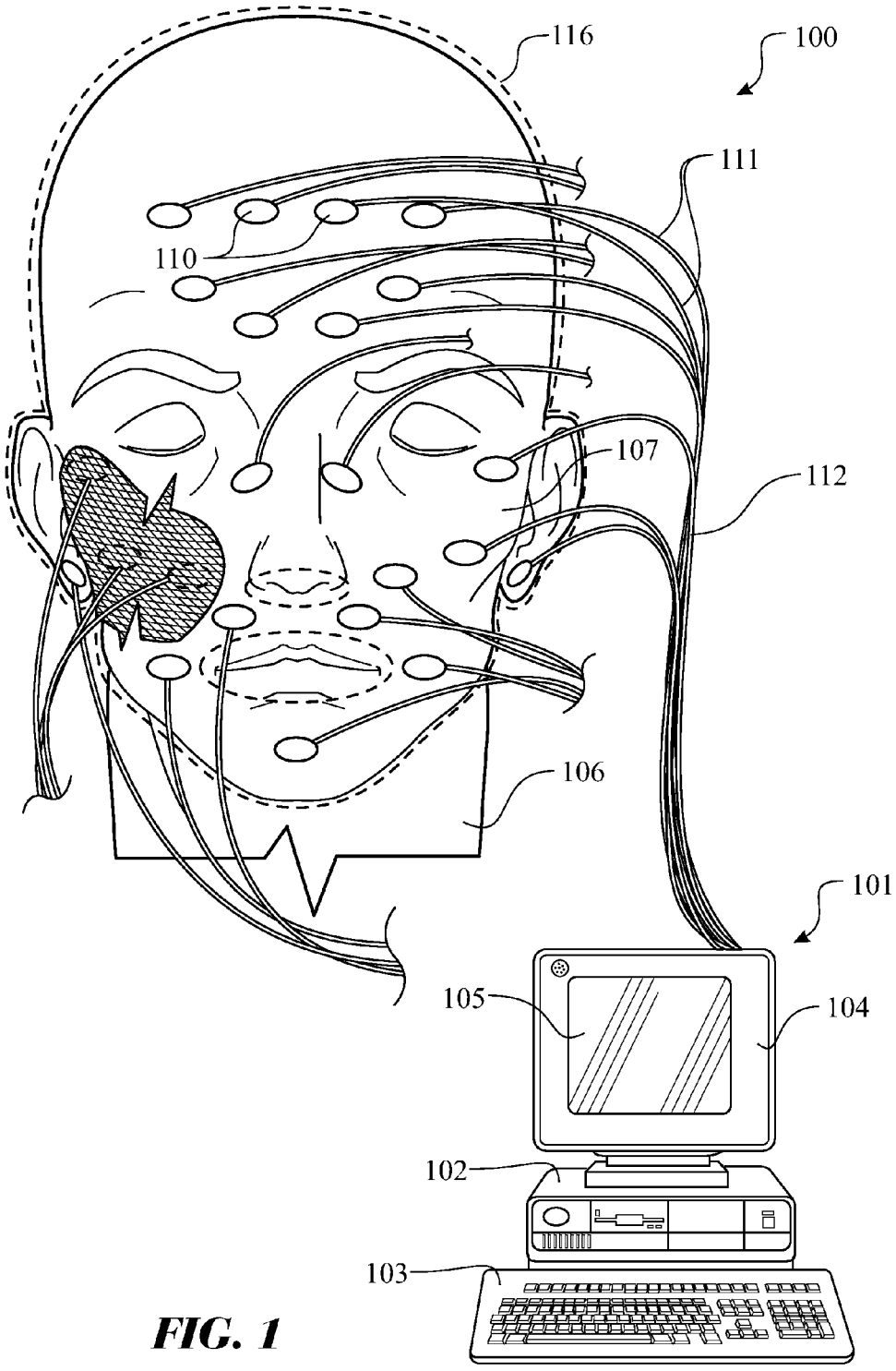


FIG. 1

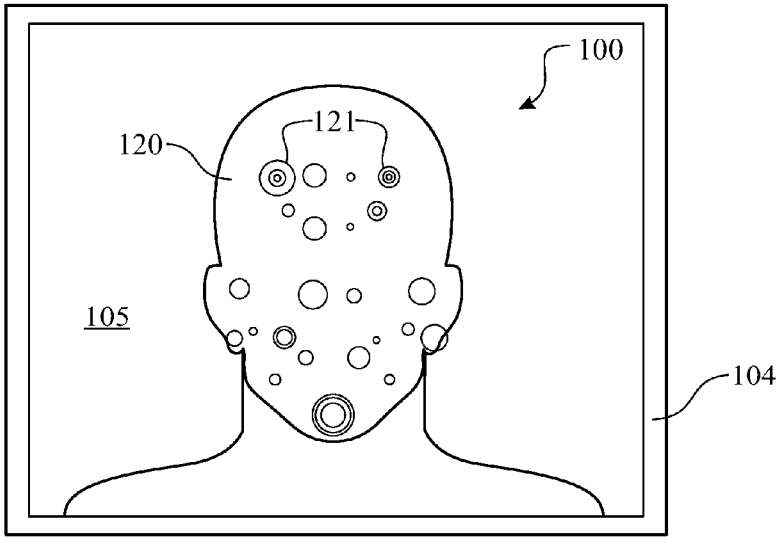

100
121
120
105
104

FIG. 2

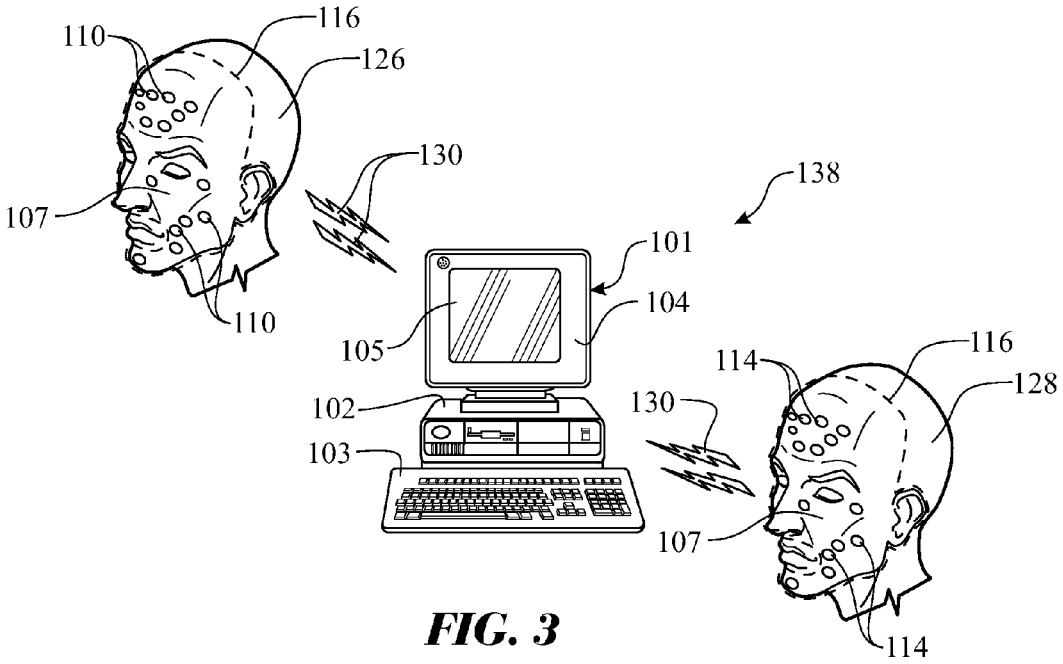

110
116
126
130
138
107
101
104
105
114
116
128
102
130
103
107
110
114

FIG. 3

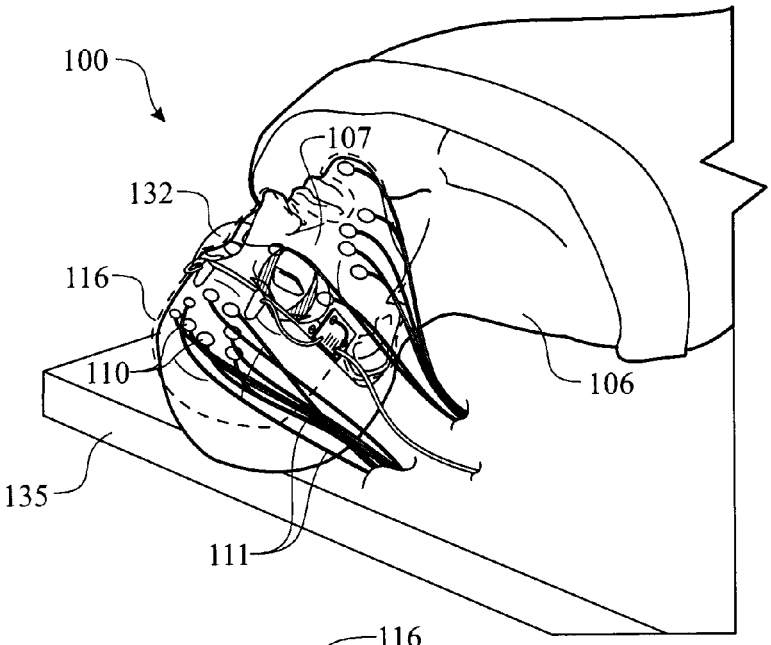

100
107
132
116
110
106
135
111

FIG. 4

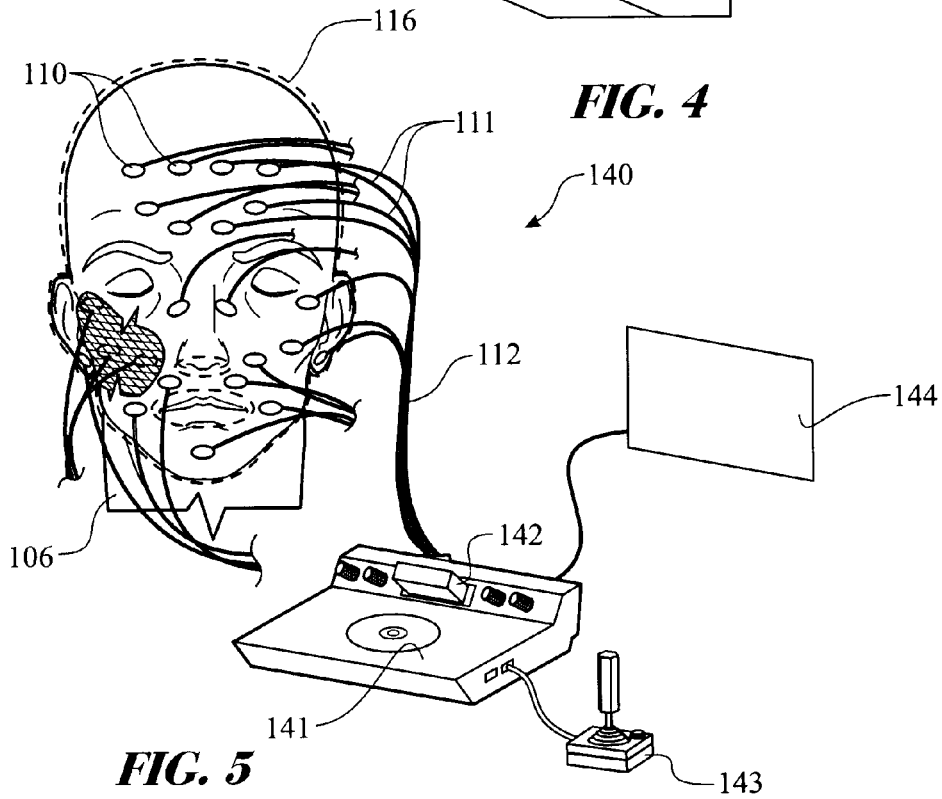

116
110
111
140
112
144
106
142
141
143

FIG. 5

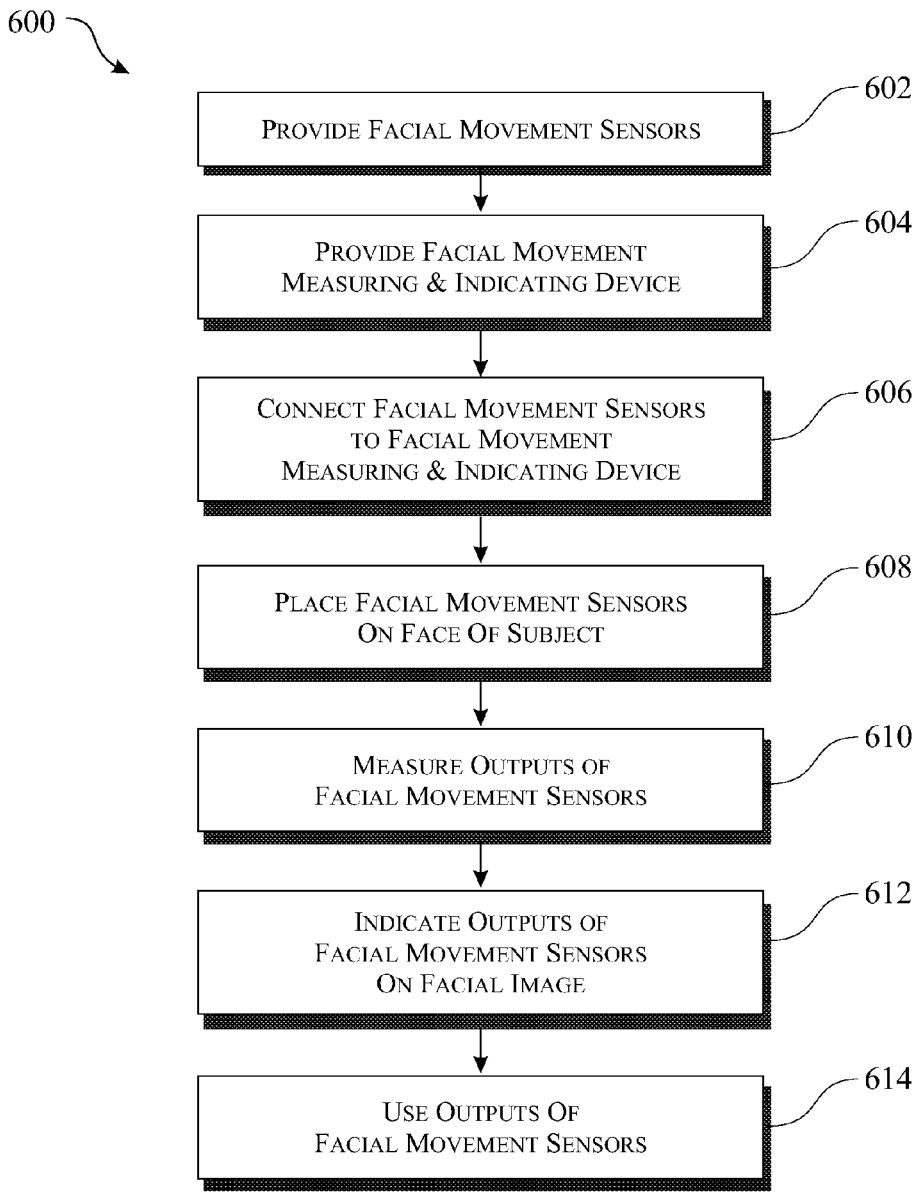

600
PROVIDE FACIAL MOVEMENT SENSORS
602
PROVIDE FACIAL MOVEMENT MEASURING & INDICATING DEVICE
604
CONNECT FACIAL MOVEMENT SENSORS TO FACIAL MOVEMENT MEASURING & INDICATING DEVICE
606
PLACE FACIAL MOVEMENT SENSORS ON FACE OF SUBJECT
608
MEASURE OUTPUTS OF FACIAL MOVEMENT SENSORS
610
INDICATE OUTPUTS OF FACIAL MOVEMENT SENSORS ON FACIAL IMAGE
612
USE OUTPUTS OF FACIAL MOVEMENT SENSORS
614

FIG. 6

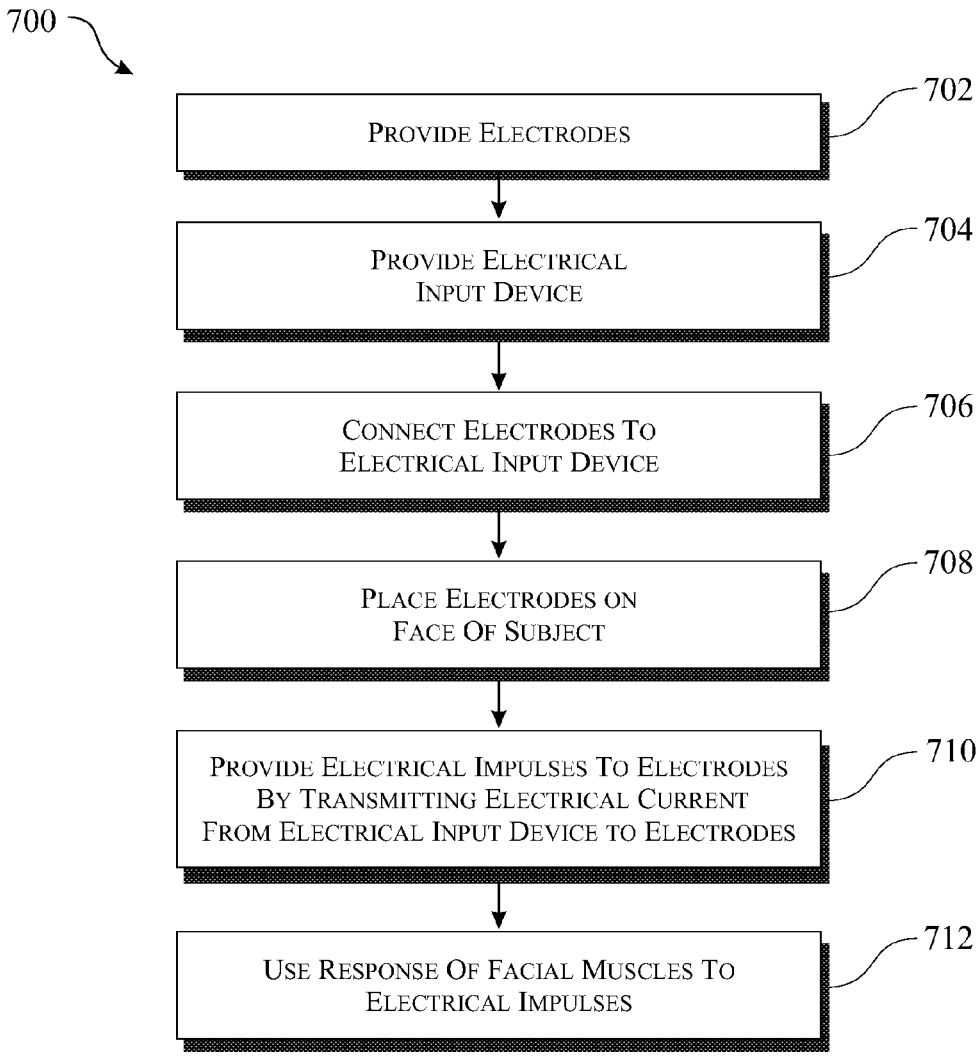

700
PROVIDE ELECTRODES
702
PROVIDE ELECTRICAL INPUT DEVICE
704
CONNECT ELECTRODES TO ELECTRICAL INPUT DEVICE
706
PLACE ELECTRODES ON FACE OF SUBJECT
708
PROVIDE ELECTRICAL IMPULSES TO ELECTRODES BY TRANSMITTING ELECTRICAL CURRENT FROM ELECTRICAL INPUT DEVICE TO ELECTRODES
710
USE RESPONSE OF FACIAL MUSCLES TO ELECTRICAL IMPULSES
712

FIG. 7

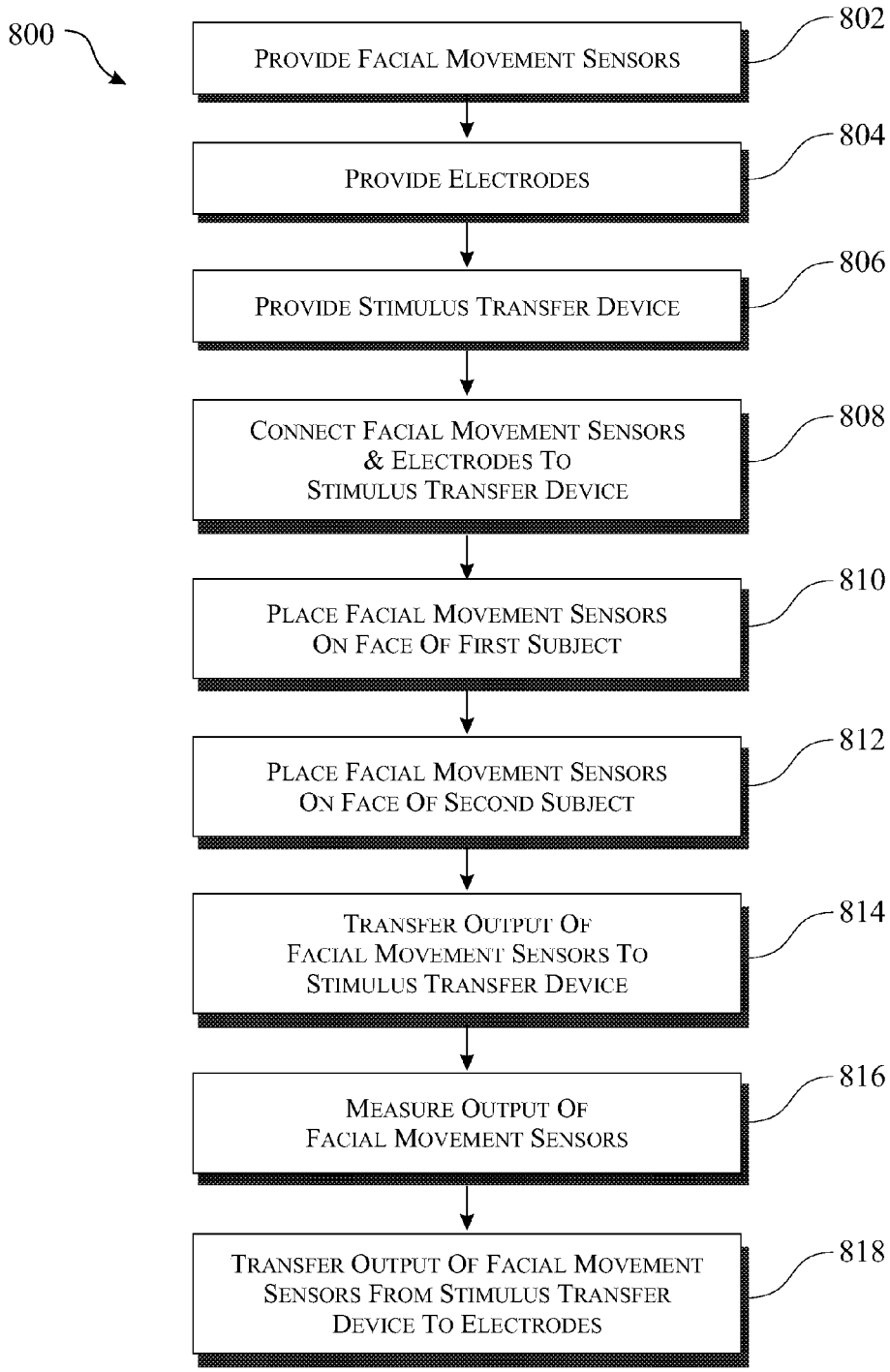

800
PROVIDE FACIAL MOVEMENT SENSORS
802
PROVIDE ELECTRODES
804
PROVIDE STIMULUS TRANSFER DEVICE
806
CONNECT FACIAL MOVEMENT SENSORS & ELECTRODES TO STIMULUS TRANSFER DEVICE
808
PLACE FACIAL MOVEMENT SENSORS ON FACE OF FIRST SUBJECT
810
PLACE FACIAL MOVEMENT SENSORS ON FACE OF SECOND SUBJECT
812
TRANSFER OUTPUT OF FACIAL MOVEMENT SENSORS TO STIMULUS TRANSFER DEVICE
814
MEASURE OUTPUT OF FACIAL MOVEMENT SENSORS
816
TRANSFER OUTPUT OF FACIAL MOVEMENT SENSORS FROM STIMULUS TRANSFER DEVICE TO ELECTRODES
818

FIG. 8

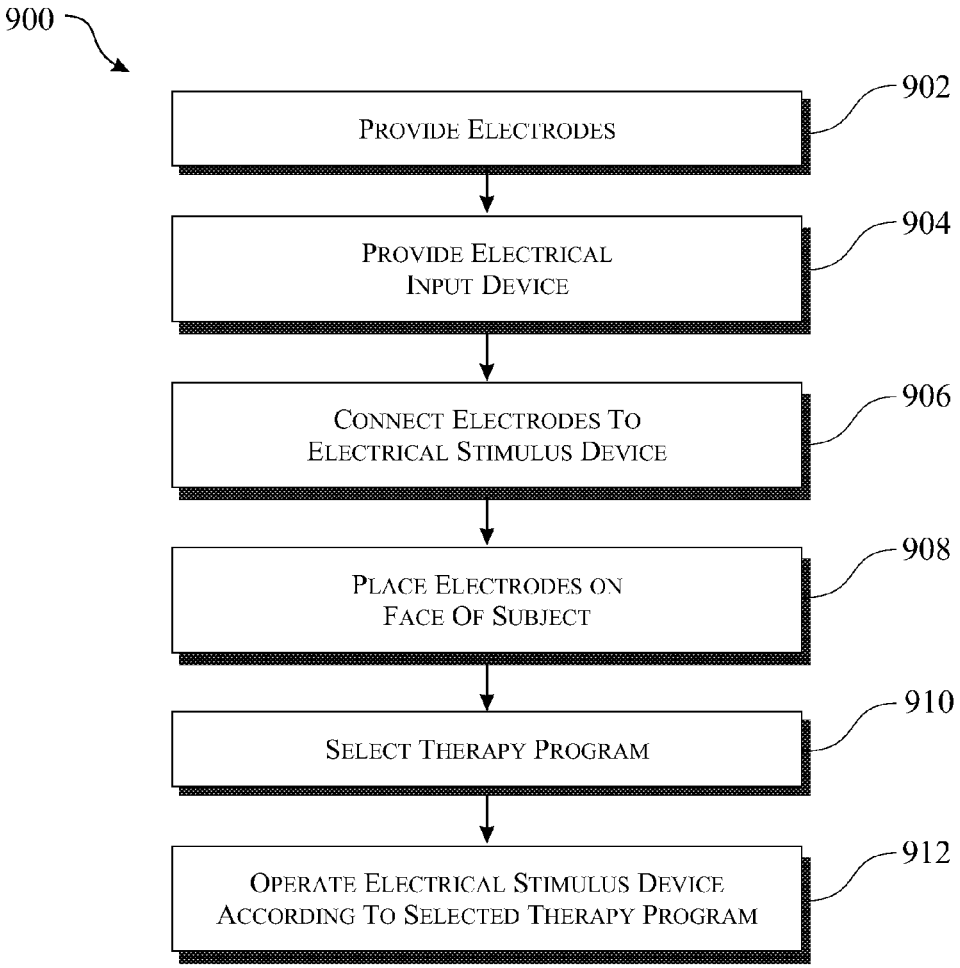

900
PROVIDE ELECTRODES
902
PROVIDE ELECTRICAL INPUT DEVICE
904
CONNECT ELECTRODES TO ELECTRICAL STIMULUS DEVICE
906
PLACE ELECTRODES ON FACE OF SUBJECT
908
SELECT THERAPY PROGRAM
910
OPERATE ELECTRICAL STIMULUS DEVICE ACCORDING TO SELECTED THERAPY PROGRAM
912

FIG. 9

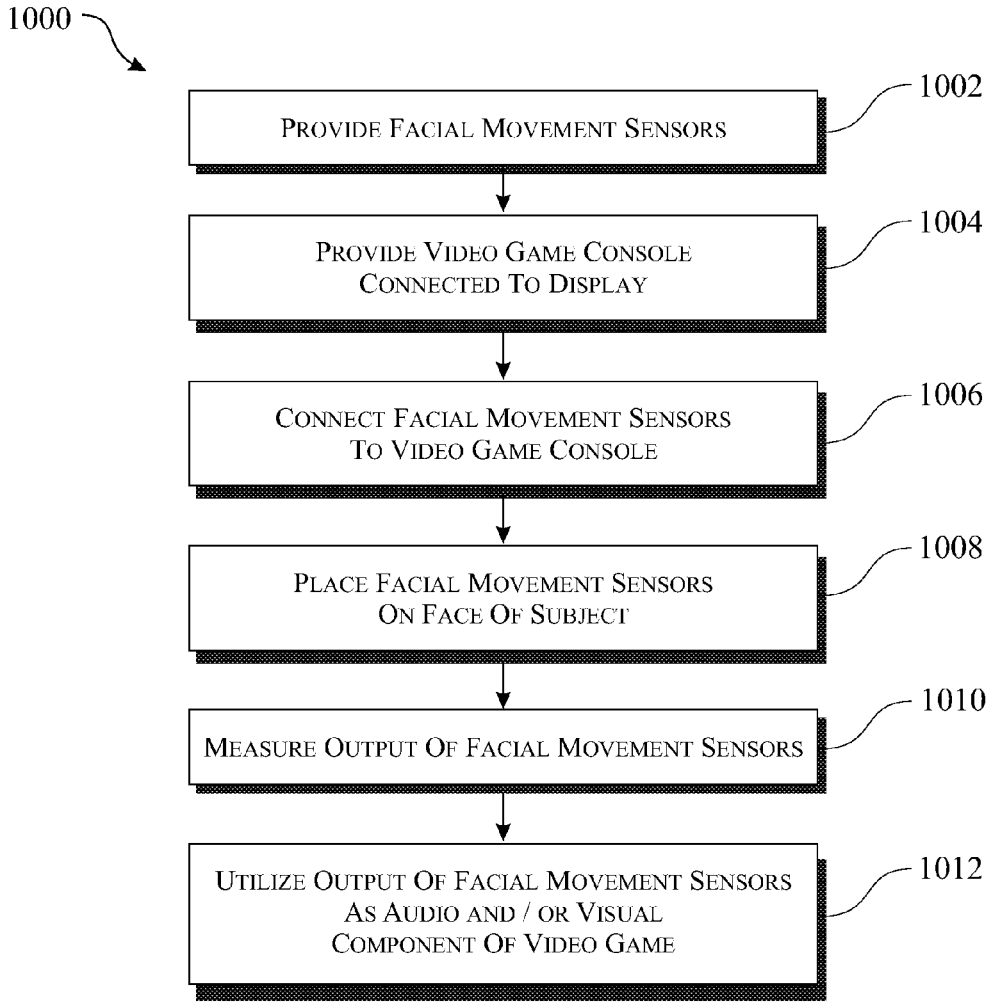

1000
PROVIDE FACIAL MOVEMENT SENSORS
1002
PROVIDE VIDEO GAME CONSOLE CONNECTED TO DISPLAY
1004
CONNECT FACIAL MOVEMENT SENSORS TO VIDEO GAME CONSOLE
1006
PLACE FACIAL MOVEMENT SENSORS ON FACE OF SUBJECT
1008
MEASURE OUTPUT OF FACIAL MOVEMENT SENSORS
1010
UTILIZE OUTPUT OF FACIAL MOVEMENT SENSORS AS AUDIO AND / OR VISUAL COMPONENT OF VIDEO GAME
1012

FIG. 10

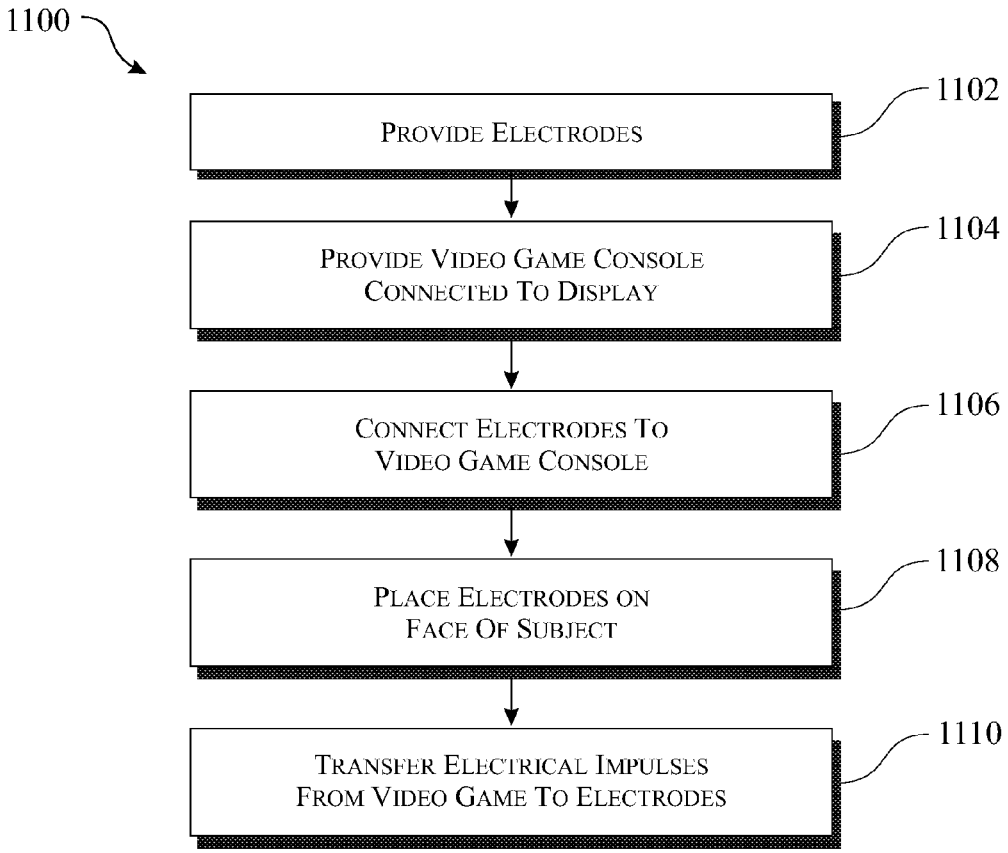

1100
PROVIDE ELECTRODES
1102
PROVIDE VIDEO GAME CONSOLE CONNECTED TO DISPLAY
1104
CONNECT ELECTRODES TO VIDEO GAME CONSOLE
1106
PLACE ELECTRODES ON FACE OF SUBJECT
1108
TRANSFER ELECTRICAL IMPULSES FROM VIDEO GAME TO ELECTRODES
1110

FIG. 11

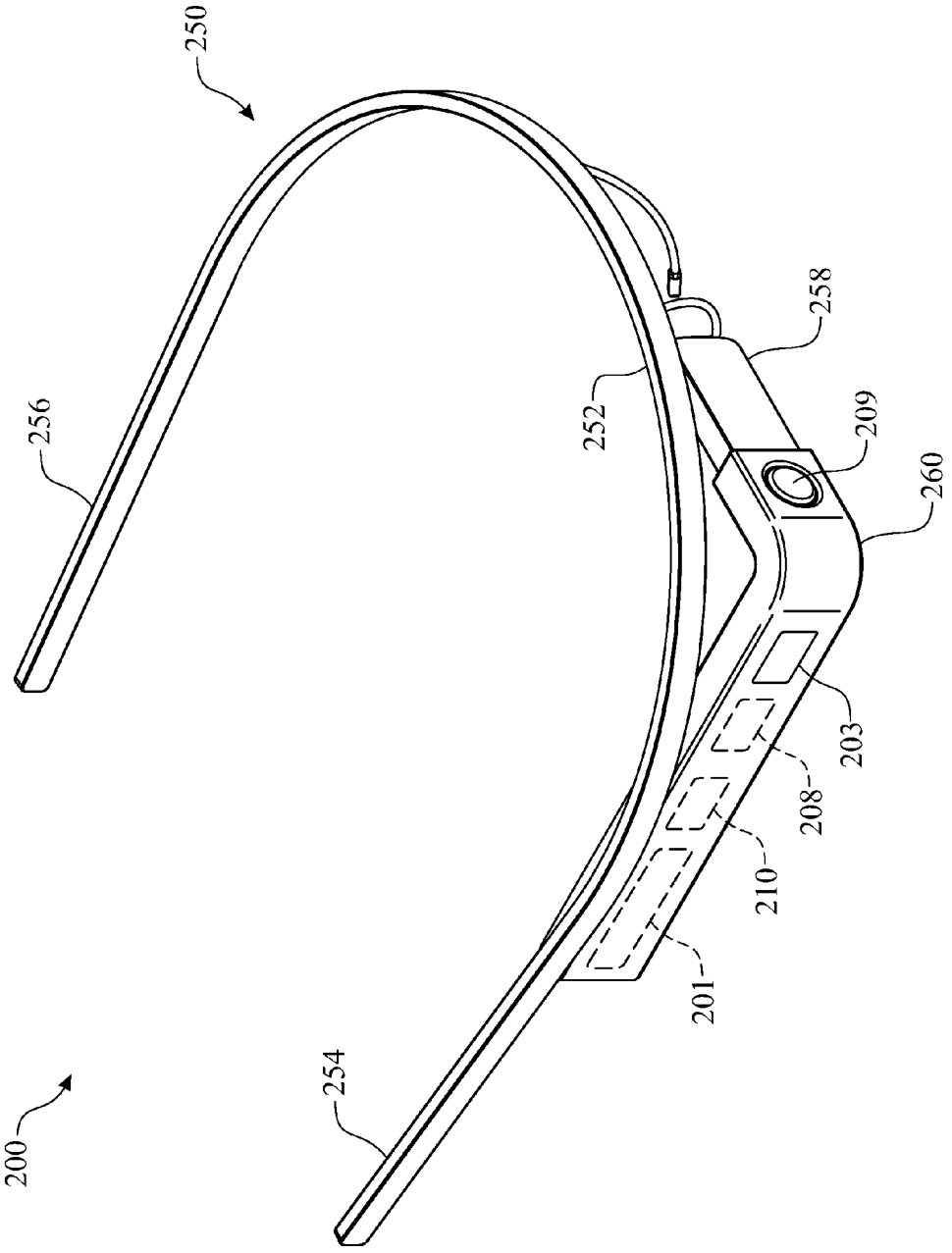


FIG. 12

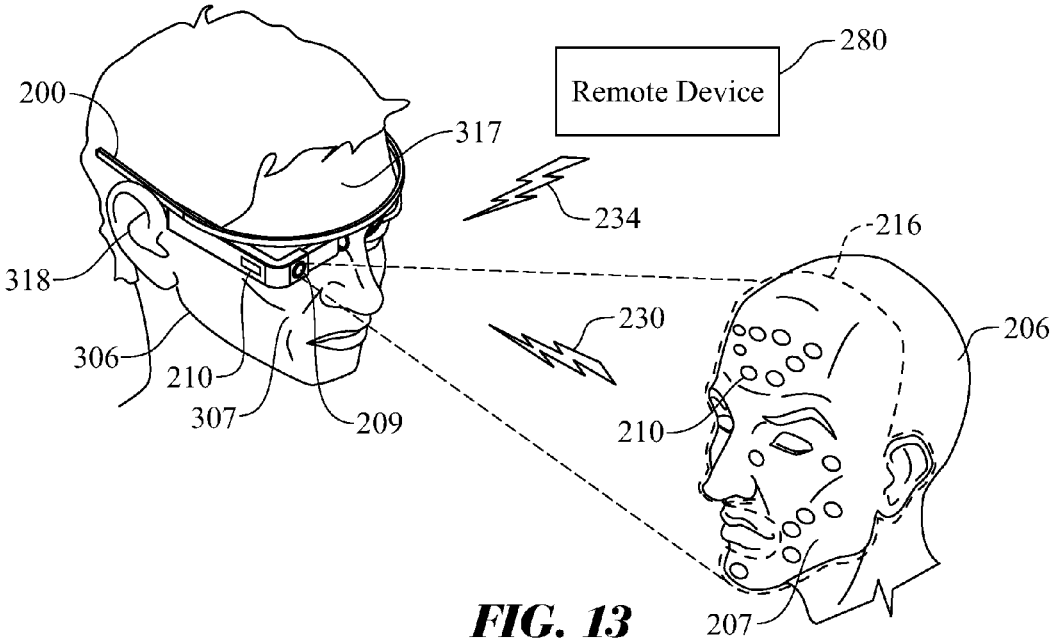

200
317
Remote Device
280
234
216
318
230
206
306
210
307
209
210
207

FIG. 13

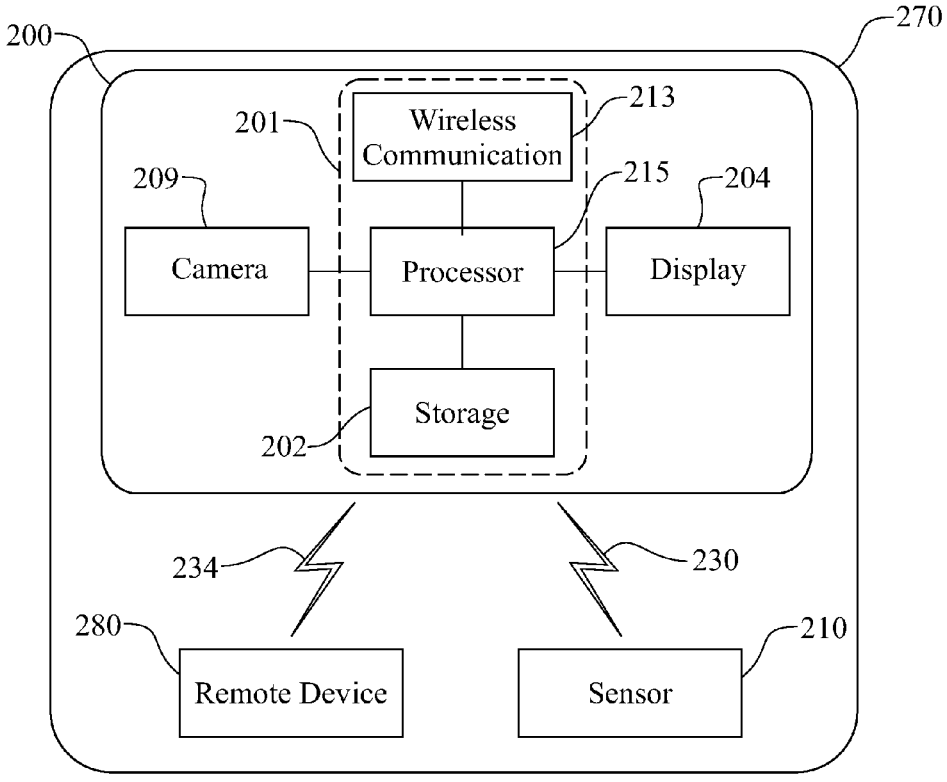

200
270
201
Wireless Communication
213
209
215
204
Camera
Processor
Display
Storage
202
234
230
280
210
Remote Device
Sensor

FIG. 14

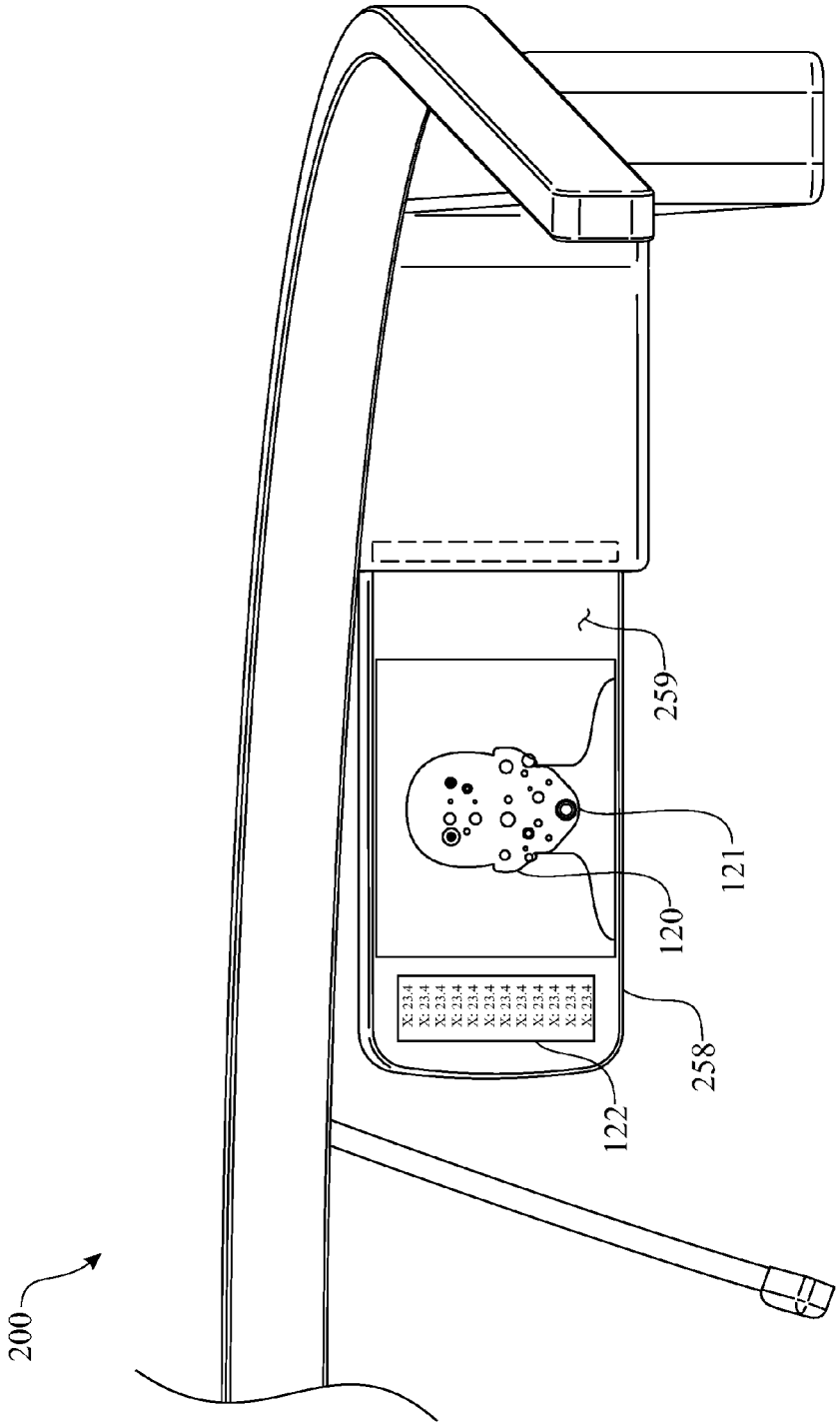


FIG. 15

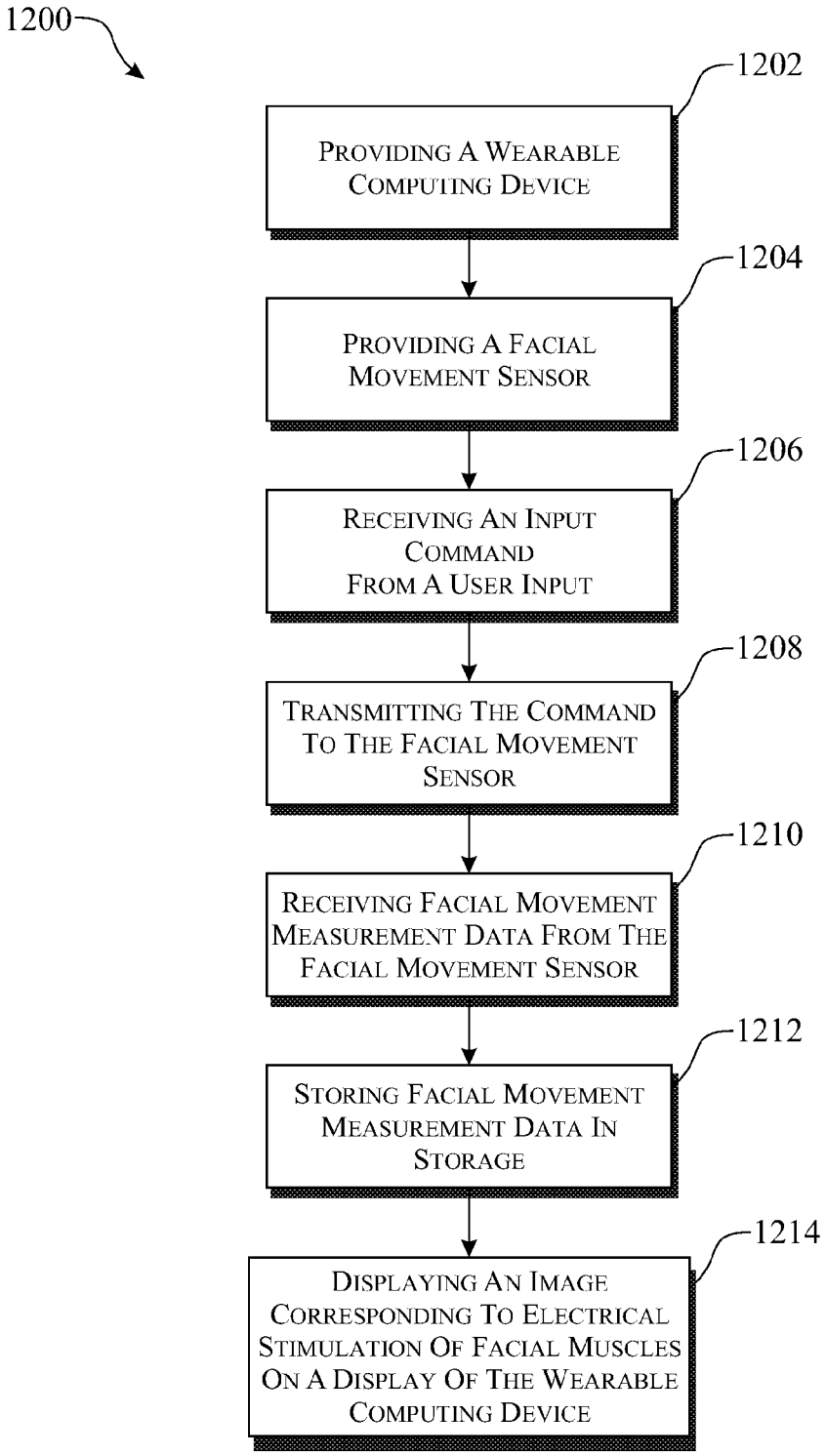

1200
1202
PROVIDING A WEARABLE COMPUTING DEVICE
1204
PROVIDING A FACIAL MOVEMENT SENSOR
1206
RECEIVING AN INPUT COMMAND FROM A USER INPUT
1208
TRANSMITTING THE COMMAND TO THE FACIAL MOVEMENT SENSOR
1210
RECEIVING FACIAL MOVEMENT MEASUREMENT DATA FROM THE FACIAL MOVEMENT SENSOR
1212
STORING FACIAL MOVEMENT MEASUREMENT DATA IN STORAGE
1214
DISPLAYING AN IMAGE CORRESPONDING TO ELECTRICAL STIMULATION OF FACIAL MUSCLES ON A DISPLAY OF THE WEARABLE COMPUTING DEVICE

FIG. 16

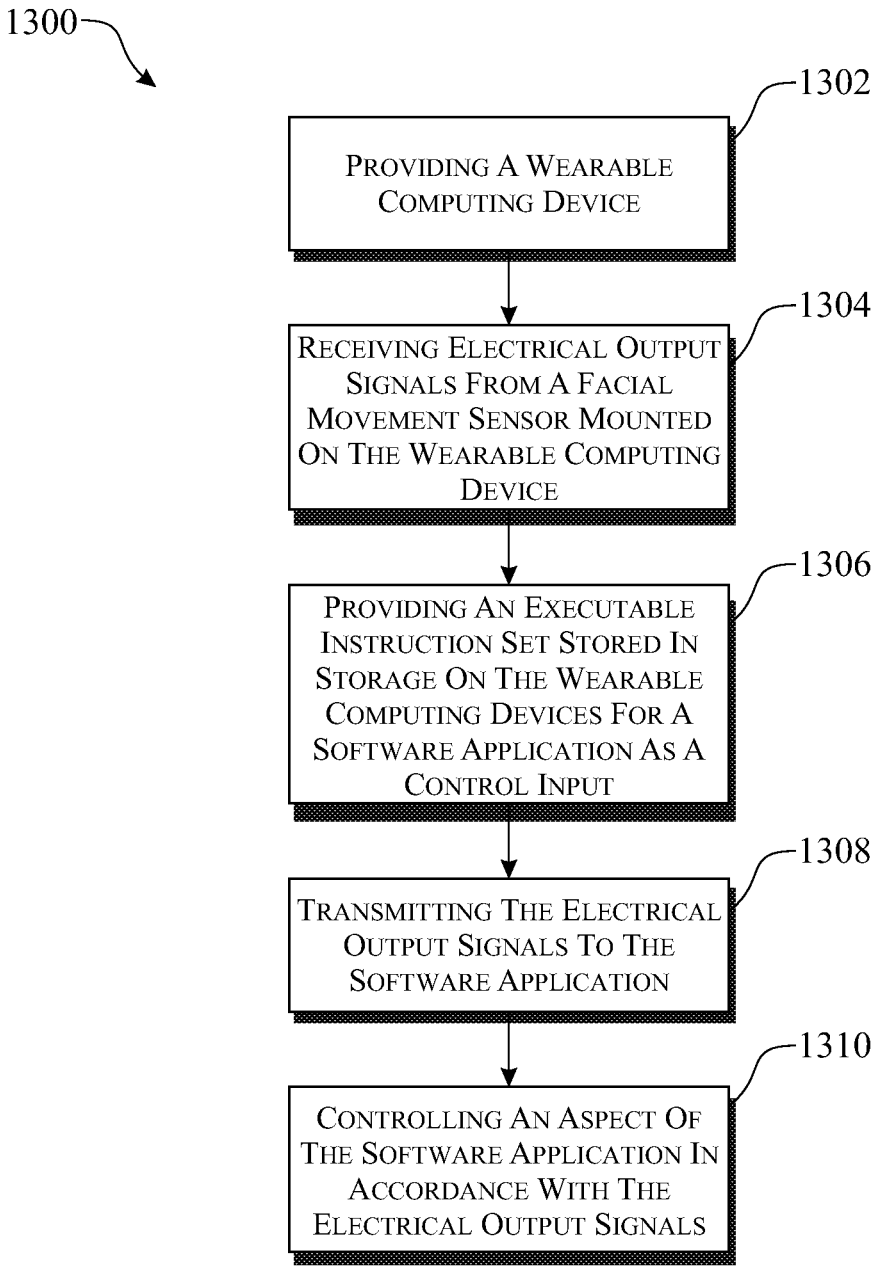

1300
1302
PROVIDING A WEARABLE COMPUTING DEVICE
1304
RECEIVING ELECTRICAL OUTPUT SIGNALS FROM A FACIAL MOVEMENT SENSOR MOUNTED ON THE WEARABLE COMPUTING DEVICE
1306
PROVIDING AN EXECUTABLE INSTRUCTION SET STORED IN STORAGE ON THE WEARABLE COMPUTING DEVICES FOR A SOFTWARE APPLICATION AS A CONTROL INPUT
1308
TRANSMITTING THE ELECTRICAL OUTPUT SIGNALS TO THE SOFTWARE APPLICATION
1310
CONTROLLING AN ASPECT OF THE SOFTWARE APPLICATION IN ACCORDANCE WITH THE ELECTRICAL OUTPUT SIGNALS

FIG. 17

FACIAL MOVEMENT MEASUREMENT AND STIMULATION APPARATUS AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This Continuation-In-Part Utility Application claims the benefit of co-pending U.S. Non-Provisional patent application Ser. No. 12/427,739, filed on Apr. 21, 2009, which is incorporated herein in its entirety.

FIELD OF THE INVENTION

The present disclosure generally relates to apparatuses and methods for stimulating and measuring the movement of facial muscles. More particularly, the present disclosure relates to an apparatus and method for stimulating, measuring, and utilizing facial muscle movement data with a wearable computing device.

BACKGROUND OF THE INVENTION

Facial expressions, while displayed by many animal species, are most highly developed in primates and most particularly in humans. Although humans have developed a great capacity to communicate using verbal language, the role of facial expressions in interpersonal interactions remains substantial. Facial expressions provide a means of understanding a person's innermost thoughts and emotions, which may defy interpretation by verbal means alone. Therefore, facial expressions in combination with verbal expressions tend to more accurately convey the intended thoughts, feelings and intentions of a person than can be conveyed through verbal expressions only. Moreover, facial expressions and the underlying emotions of which they are a manifestation tend to be contagious, as a person who sees a smiling person is likely to embrace and reflect the positive emotions of that person by smiling as well.

Restoration of a person's lost ability to properly express his or her thoughts and emotions through facial expressions or training of a person in mimicking facial expressions may be desirable in a variety of contexts. In some cases, the ability of a person to express his or her underlying thoughts and emotions accurately through appropriate facial expressions, or the ability of a person to change facial expressions according to changing thoughts and emotions, may diminish or disappear due to causes such as disease, accident or drug abuse, for example. Additionally, actors-in-training may encounter challenges in reacting to staged situations with appropriate facial expressions, which may be more naturally assumed by persons who encounter the actual situations.

Moreover, computing devices such as personal computers, computer tablets, cellular phones and other handheld computing devices are becoming more prevalent and integral to aspects of modern day living. As such computing devices are rapidly decreasing in size and there is a desire to integrate such computing devices into everyday items in modern living, such as integrating computing capabilities into wearable items.

Therefore, a facial movement measurement and stimulation apparatus for measuring and/or stimulating movement of facial muscles and utilizing such data in wearable computing devices is needed.

SUMMARY OF THE INVENTION

The present disclosure is generally directed to a facial movement measurement and stimulation apparatus and method for measuring and/or stimulating movement of facial muscles in a variety of applications. In some applications, the apparatus and method may determine a person's ability to assume facial expressions by measuring the electrical activity or movement of the person's facial muscles. In some applications, the apparatus and method may be implemented in a therapeutic context in which a person is trained to assume facial expressions that accurately reflect the person's underlying thoughts and emotions or the person is trained to change facial expressions to accurately reflect the person's changing thoughts and emotions. In some applications, the apparatus and method may be used to train a person in mimicking facial expressions in response to staged situations. In some applications, the goals of the apparatus and method may be implemented by facilitating the sharing or transfer of facial expressions between two or more subjects.

In some embodiments, the facial movement measurement and stimulation apparatus may include:

at least one facial movement sensor adapted to sense facial movement in a subject; and

a device interfacing with the facial movement sensor and adapted to receive at least one signal from the facial movement sensor and indicate facial movement of the subject.

In another aspect, the at least one facial movement sensor may include at least one electrode.

In still another aspect, the at least one facial movement sensor may include at least one accelerometer.

In yet another aspect, the device may include a video game console.

In a still further aspect, the facial movement sensor or sensors may be provided on a mask.

In another aspect, at least one electrode may interface with the device and the device may be adapted to transmit at least one electrical impulse to the at least one electrode.

In another aspect, one or more low level electrical impulses may, instead of causing firing of the muscles, be provided to cause sensory stimulation as a means for regulating emotions.

In a still further aspect, the at least one facial movement sensor may be provided on a first mask and the at least one electrode may be provided in a second mask.

In yet another aspect, the at least one facial movement sensor may interface with the device through wiring.

In another aspect, the at least one facial movement sensor may interface with the device wirelessly.

In still another aspect, the device may include a computer having a display and the computer may be adapted to indicate facial movement of the subject on the display.

In yet another aspect, the computer may be adapted to present a facial image on the display and present at least one facial movement indication on the facial image.

In another aspect, the at least one facial movement sensor may include a plurality of facial movement sensors.

In still another aspect, the facial expression and the stimulation can be treated as a feedback loop that can be monitored and regulated.

In still another aspect, there is provided a wearable computing system, comprising:

eyeglasses, comprising:

a lens element including a display,

a frame with side arms extending therefrom, and

an eyeglasses body adapted to function as a computing system housing, the computer system housing comprising a computer having a processor, storage, and a wireless communication device; and

at least one sensor adapted to measure facial muscle movement in a user, the at least one sensor in electrical communication with the computer.

In yet another aspect, the at least one sensor is a camera having a camera lens mounted on the eyeglasses such that when the eyeglasses are worn by the user, the camera lens is directed toward the user's face and is configured to capture one at least one of a still image and video of the face, and wherein the processor is configured to receive and compare captured images and video to generate facial movement measurement data therefrom.

In yet another aspect, the at least one sensor is an electrode in electrically conductive communication with a facial muscle of the user and is adapted to transmit an electrical impulse to the facial muscle of the user to electrically stimulate the facial muscle.

In yet another aspect, the wearable computing system further comprises a mask, and the at least one electrode comprises a plurality of electrodes that are carried by the mask.

In another aspect, the mask extends from the eyeglasses.

In another aspect, the plurality of electrodes are located at each of a top portion, a middle portion, and a bottom portion of the face, wherein the top portion, corresponds to the user's forehead area, and wherein the middle portion corresponds to the user's eye and nose area, and wherein the bottom portion corresponds to the user's mouth area.

In another aspect, the at least one electrode comprises a plurality of electrodes mounted on the eyeglasses such that when the eyeglasses are worn by the user, the plurality of electrodes are in electrically conductive communication with the user's facial muscles.

In another aspect, the computer is adapted to output facial muscle movement signals, indicative of facial muscle movement of the user, to the display of the eyeglasses.

In another aspect, the wearable computing system further comprises an instruction set stored in computer storage corresponding to video game software.

In another aspect, the electrical impulse corresponds to a movement of a video game character presented on the display.

In yet another aspect, there is provided a method of measuring and indicating facial movement of a user, comprising steps of providing a wearable computing device having a processor, storage, a user input, and a display; and providing at least one facial movement sensor mounted on the wearable computing device such that the at least on facial movement sensor is directed toward the user's face when the wearable computing system is worn by the user. The wearable computing device receives an input command from the user input commanding the at least one facial movement sensor to transmit an electrical impulse to provide facial movement stimulation to the user's facial muscles. The wearable computing device then transmits the command to the at least one facial movement sensor and receives facial movement measurement data from the at least one facial movement sensor, which data corresponds to nerve-induced electrical stimulation of the user's facial muscles. Furthermore, the wearable computing system can store facial movement measurement data in storage and display an image corresponding to the nerve-induced electrical stimulation of facial muscles on the display of the wearable computing device. Moreover, the wearable computing device may be in the form of one of a group of eyeglasses, a mask, and contact lenses. The facial movement sensor may be a camera having a camera lens directed toward the user's face and the camera can capture at least one of a still image and video of the face. The processor of the computing device can compare the captured images and video of the face and generate facial movement measurement data therefrom. Alternatively, the facial movement sensor can be a plurality of electrodes in electrically conductive communication with facial muscles of the user and the electrodes can transmit an electrical impulse to facial muscles of the user to electrically stimulate the user's facial muscles.

In yet another aspect, there is provided a method of utilizing facial movement data, comprising the steps of providing a wearable computing device adapted to be worn on a user's face and receiving electrical output signals from at least one facial movement sensor mounted on the wearable computing device such that the at least one facial movement sensor is directed toward the user's face when the wearable computing system is worn by the user. The method further includes providing an executable instruction set stored in storage on the wearable computing device, the instruction set providing instructions for a software application adapted to utilize the output signal of the at least one facial movement sensor as a control input; and transmitting the electrical output signals to the software application. An aspect of the software application is controlled in accordance with the electrical output signals from the at least one facial movement sensor. The facial movement sensors can be one of a plurality of electrodes in electrically conductive communication with facial muscles of the user and a camera having a camera lens directed toward the user's face. Furthermore, the method can include providing instructions for a video game and controlling one of an audio component and a video component of the video game in accordance with the electrical output signals.

These and other advantages of the invention will be further understood and appreciated by those skilled in the art by reference to the following written specification, claims and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example, with reference to the accompanying drawings, where like numerals denote like elements and in which:

FIG. **1** presents a front view of an illustrative embodiment of the facial movement measurement and stimulation apparatus (partially in section), with multiple electrodes attached to a face of a subject (shown in section) in an implementation of the apparatus;

FIG. **2** presents a front view of a computer monitor of an illustrative embodiment of the apparatus, with a facial image of the subject presented on the monitor and multiple facial movement indications presented on the facial image and indicating movement of the subject's facial muscles in the locations that correspond to the facial movement indications;

FIG. **3** illustrates implementation of an illustrative embodiment of the apparatus, in which facial movements are transferred or shared between two subjects via wireless communication with a computer;

FIG. **4** presents a perspective view of a subject lying on a support (partially in section), with multiple electrodes of an illustrative embodiment of the apparatus attached to the face of the subject and oculography glasses worn by the subject to monitor sleep phases;

FIG. **5** presents a front view of an alternative illustrative embodiment of the apparatus (partially in section), with multiple electrodes attached to a face of a subject (shown in section) and the electrodes connected to a video game in implementation of the apparatus;

FIG. **6** presents a flow diagram of an illustrative embodiment of a facial movement measurement method in which facial movements of a subject are measured;

FIG. **7** presents a flow diagram of an illustrative embodiment of a facial movement stimulation method in which facial movements are stimulated in a subject;

FIG. **8** presents a flow diagram of an illustrative embodiment of a facial movement stimulation method in which facial movements are transferred from a first subject to a second subject;

FIG. **9** presents a flow diagram of an illustrative embodiment of a therapeutic facial movement stimulation method;

FIG. **10** presents a flow diagram of an illustrative embodiment of a facial movement measurement method in which facial movements of a subject are utilized in a video game;

FIG. **11** presents a flow diagram of an illustrative embodiment of the facial movement stimulation method in which electrical stimuli from a video game are transferred to a subject to effect facial movements in the subject;

FIG. **12** presents an isometric view of a wearable computing device for receiving, transmitting, and displaying data, in accordance with an exemplary embodiment;

FIG. **13** presents an isometric view of an exemplary embodiment, showing the wearable computing device, originally introduced in FIG. **12**, and illustrating facial movement being detected by sensors, received by the wearable computing device, and transmitted to a remote device via wireless communication;

FIG. **14** presents a schematic diagram of a computer network infrastructure, in accordance with an exemplary embodiment;

FIG. **15** presents an isometric front view of a display of the wearable computing device, originally introduced in FIG. **12**, showing an image presented on the display, the image corresponding to facial movement data received by the wearable computing device.

FIG. **16** presents a flow chart illustrating a method according to an exemplary embodiment in which facial movement data is received, stored, and displayed by a wearable computing device; and

FIG. **17** presents a flow chart illustrating a method according to an exemplary embodiment in which facial movement data received by a wearable computing device is provided as a control input to a software application running on a remote device or the wearable computing device.

Like reference numerals refer to like parts throughout the various views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description is merely exemplary in nature and is not intended to limit the described embodiments or the application and uses of the described embodiments. As used herein, the word "exemplary" or "illustrative" means "serving as an example, instance, or illustration." Any implementation described herein as "exemplary" or "illustrative" is not necessarily to be construed as preferred or advantageous over other implementations. All of the implementations described below are exemplary implementations provided to enable persons skilled in the art to make or use the embodiments of the disclosure and are not intended to limit the scope of the disclosure which is defined by the claims. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

The present disclosure is generally directed to a facial movement measurement and stimulation apparatus and method for measuring and/or stimulating movement of facial muscles in a variety of applications. In some applications, the apparatus and method may determine a person's ability to make facial movements or assume facial expressions by measuring the electrical activity or movement of the person's facial muscles. In some applications, the apparatus and method may be implemented in a therapeutic context in which a person is trained to assume facial expressions that accurately reflect the person's underlying thoughts and emotions or the person is trained to change facial expressions to accurately reflect the person's changing thoughts and emotions. Alternatively, the stimulation can be provided at a low enough level to cause sensory stimulation without causing firing of the muscles. In some applications, the apparatus and method may be used to train a person in mimicking facial expressions in response to staged situations. In some applications, the goals of the apparatus and method may be attained by facilitating the sharing or transfer of facial movements or expressions between two or more subjects.

Referring initially to FIGS. **1** and **2** of the drawings, an illustrative embodiment of the facial movement measurement and stimulation apparatus, hereinafter apparatus, is generally indicated by reference numeral **100** in FIG. **1**. In some applications, the apparatus **100** may function as an electromyographic measurement system to measure movements of facial muscles (not illustrated) in the face **107** of a subject **106** for any of a variety of purposes. For example, lack or impairment of movement of the facial muscles in the face **107** of the subject **106**, as interpreted by the apparatus **100**, may reveal a medical condition (such as facial paralysis due to a stroke, for example) and provide the basis for a medical diagnosis and/or therapeutic treatment regimen for the medical condition. Accordingly, the apparatus **100** may include multiple electrodes **110**, which in some applications may function as facial movement sensors that may be placed on the skin (not illustrated) at various locations on the face **107** of the subject **106** to measure movement of the musculature (not illustrated) in the face **107**. The locations of the electrodes **100** may correspond in position to individual muscles (not illustrated) of the facial musculature, which underlies the skin in the face **107**. In some applications, the electrodes **100** may be confined to a portion of the face **107**. In some applications, the electrodes **100** may be placed over the entire face **107** and may additionally or alternatively be placed on one or both ears and/or along the neck and larynx of the subject **106**. Each electrode **100** may be adapted to measure both sporadic or continuous high-level electrical nerve stimulation and continuous, low-level electrical nerve stimulation of the muscles in the face **107**.

In some embodiments, each electrode **100** may be directly affixed to the face **107** of the subject **106** using a suitable adhesive. In other embodiments, the system **100** may include a flexible or stretchable mask **116**, which conforms to the features on the face **107**. The electrodes **110** may be provided on a contact surface (not illustrated) of the mask **116** with the skin on the face **107**. Adhesive (not illustrated) may be provided on the contact surface of the mask **116** to facilitate adhesion of the mask **116** to the skin on the face **107** and maintain electrically-conductive contact between the electrodes **110** and the skin on the face **107**. In some embodiments, the electrodes **110** may be surgically implanted in the skin at the desired locations on the face **107**.

The system **100** may further include a computer **101** which in some embodiments may be connected to the electrodes **110** through electrode wiring **111**. The electrode wiring **111** may be wrapped in a wiring bundle **112**. In other embodiments, the electrodes **110** may interface with the computer **110** through wireless transmissions **130** (FIG. **3**), according to the knowledge of those skilled in the art. The computer **101** may be conventional and may include a computer disk drive **102** with a computer keyboard **103** and a computer monitor **104** having a display **105** connected to the computer disk drive **102**. In applications in which the electrodes **110** function as facial movement sensors that measure movement of the muscula-

ture (not illustrated) in the face **107** of the subject **106**, the computer **101** may function as a facial movement measuring and indicating device which receives electrical signals from the electrodes **110** in contact with the face **107**. Accordingly, as illustrated in FIG. **2**, the computer **101** with supporting software may be programmed to display a facial image **120** on the display **105** of the computer monitor **104**. The computer **101** may additionally be programmed to convert the electrical output signals from the electrodes **110** into facial movement indications **121** and present the facial movement indications **121** on the facial image **120** in the areas of the facial image **120** which correspond to areas of muscle movement in the face **107** of the subject **106** in real time as sensed by the electrodes **110**.

The strength of the electrical output signals that the computer **101** receives from the electrodes **110** may be proportional to the level or intensity of electrical nerve stimulation and therefore, the level or intensity of contraction of the musculature in the face **107** of the subject **106**. Accordingly, the facial movement indications **121** may be adapted to visually differentiate the intensity of muscle movement in each area from the intensity of muscle movement in the other areas in the face **107** of the subject **106**. As illustrated in FIG. **2**, in some applications each facial movement indication **121** may be represented by one or multiple circles. Facial movement indications **121** having a single circle may indicate muscular contraction of relatively low-level intensity in the corresponding area or areas on the face **107**, whereas facial movement indications **121** having multiple concentric circles of increasing number may indicate muscular contraction of correspondingly increasing intensity in the corresponding area or areas on the face **107**. The information that is provided by the facial movement indications **121** may be used to formulate diagnoses and/or treatment of the subject **106** or may be used for other purposes.

In some embodiments, the facial movement sensors of the apparatus **100** may be accelerometers instead of the electrodes **110**. Accordingly, the accelerometers may be attached to or secured into contact with the skin on the face **107** of the subject **106** or alternatively, surgically implanted in the face **107** in the same manner as was heretofore described with respect to the electrodes **110**. The accelerometers sense movement of the muscles in the face **107** of the subject **106** and convert the movement of the muscles into electrical output signals that are transmitted to the computer **101** through the electrode wiring **111**. The computer **101** may convert the electrical output signals into the facial movement indications **121**, which may be presented on the facial image **120** displayed on the display **105** of the computer monitor **104**.

In some applications, the apparatus **100** may electrically stimulate movement of muscles in the face **107** of the subject **106** for any of a variety of purposes. For example, the apparatus **100** may be used in therapeutic applications to enable or train the subject **106** to make facial movements or to assume facial expressions that accurately reflect the person's underlying thoughts and emotions, for example. In some therapeutic applications, the apparatus **100** may be used to train the subject **106** in changing facial expressions to accurately reflect the person's changing thoughts and emotions, for example. In some therapeutic applications, the apparatus **100** may be used to provide a low level stimulus, which causes sensory stimulation for regulation of emotions without causing firing of the muscles. In some therapeutic applications, the apparatus **100** may be used for clinical treatment of headaches, depression, anxiety and the like. In some applications, the apparatus **100** may be used to train a person in accurately mimicking or portraying facial expressions in response to staged situations as in the training of an actor, for example. Accordingly, in these applications the electrodes **110** may be placed on the face **107** of the subject **106** as was heretofore described with respect to the muscle movement measurement functions of the apparatus **100**. The computer **101** with supporting software may function as an electrical input device which may be programmed to transmit electrical impulses to the electrodes **110** through the electrode wiring **111** in such a pattern and with such an intensity as to electrically stimulate and contract the musculature in the face **107** and induce the desired facial movements or expressions in the face **107** of the subject **106**. In some applications, the computer **101** may be programmed to effect changing facial expressions in the face **107** of the subject **106** by changing the pattern and intensity of the electrical impulses that are transmitted to the electrodes **110**.

Referring next to FIG. **3** of the drawings, an alternative illustrative embodiment of the facial movement measurement and stimulation apparatus is generally indicated by reference numeral **138**. The apparatus **138** may be adapted to transfer voluntary or involuntary facial movements or expressions from a first subject **126** to a second subject **128** in any of a variety of applications. For example, in some applications the apparatus **138** may transfer voluntary facial movements or expressions from the first subject **126**, who may be an acting trainer, to the second subject **128**, who may be an actor-in-training. In such applications, the first subject **126** may use the apparatus **138** to train the second subject **128** to accurately mimic or portray facial expressions in response to various staged situations such as those which may occur during dramatic productions, for example. In some applications, the apparatus **138** may be used to facilitate the sharing of emotions between the first subject **126** and the second subject **128** via facial expressions.

The apparatus **138** may include a first set of electrodes **110** for placement on or surgical implantation in the face **107** of the first subject **126** and a second set of electrodes **114** for placement on or surgical implantation in the same corresponding areas on the face **107** of the second subject **128**, either with or without the mask **116** as was heretofore described with respect to FIG. **1**. The first set of electrodes **110** may function as facial movement sensors which sense movement of the various muscles in the face **107** of the first subject **126** via typically voluntary nerve-induced electrical stimulation of the facial muscles. In some embodiments, the facial movement sensors may be a set of accelerometers which are applied instead of the first set of electrodes **110** to the face **107** of the first subject **126** and which sense movement of the facial muscles. The second set of electrodes **114** may electrically stimulate movement of the various muscles in the face **107** of the second subject **128** according to the intensities and locations of the muscle movements in the face **107** of the first subject **126**. Therefore, the computer **101** with supporting software may function as a stimulus transfer device which transfers the muscle movements in the face **107** of the first subject **126**, received via the first set of electrodes **110**, to the muscles in the face **107** of the second subject **128** via the second set of electrodes **114**. In some embodiments, the first set of electrodes **110** and the second set of electrodes **114** may interface with the computer **101** via electrode wiring **111**, as was heretofore described with respect to the apparatus **100** in FIG. **1**. In other embodiments, the first set of electrodes **110** and the second set of electrodes **114** may interface with the computer **101** via wireless transmissions **130**, as illustrated in FIG. **3**, according to the knowledge of those skilled in the art.

The computer **101** with supporting software is adapted to receive electrical signals that correspond to typically voluntary, nerve-induced electrical stimulation of the musculature in the face **107** of the first subject **126** through the first set of electrodes **110**. The computer **101** may be programmed to determine the locations and intensities of the electrical signals from the electrodes **110** on the various areas on the face **107** of the first subject **126** and transfer electrical impulses which correspond to the electrical signals to the second set of electrodes **114** which are applied to the corresponding areas on the face **107** of the second subject **128**. The locations and intensities of the electrical impulses that are transmitted to the second set of electrodes **114** correspond to the locations and intensities of the electrical signals which were received from the first set of electrodes **110**. Therefore, the electrical impulses which the second set of electrodes **114** applies to the muscles in the face **107** of the second subject **128** cause contraction of the respective facial muscles to effect the corresponding facial movements or expressions in the second subject **128** that were made by the first subject **126** as the first set of electrodes **110** transmitted the electrical signals to the computer **101**. In some embodiments, the locations and intensities of the muscle movements in the face **107** of the first subject **126** may be indicated on the display **105** of the computer **101** such as in the form of the facial movement indications **121**, as was heretofore described with respect to FIG. **2**.

Referring next to FIG. **4** of the drawings, in an alternative application of the apparatus **100**, which was heretofore described with respect to FIGS. **1** and **2**, the electrodes **110** may be applied to the face **107** of a subject **106** as the subject **106** lies on a bed or other support **135**. Oculography glasses **132** may be placed on the head of the subject **106** to record eye position and movements of the subject **106** such as in the analysis of various stages of sleep in the subject **106**, for example. The stages of sleep can include both non-REM (Rapid Eye Movements) and REM sleep periods. Criteria for REM sleep include not only rapid eye movements, but also low muscle tone and a rapid, low voltage EEG. These features are easily discernible in a polysomnogram, the sleep study typically done for patients with suspected sleep disorders. Accordingly, in use of the apparatus **100**, such as during sleep studies conducted on the subject **106**, the computer **101** (FIG. **1**) may function as a facial movement measuring and indicating device which receives from the electrodes **110** electrical signals that correspond to nerve-induced stimulation of the muscles in the face **107** of the subject **106** either through the electrode wiring **111**, as shown, or via wireless transmissions **130** as was heretofore described with respect to FIG. **3**. As was heretofore described with respect to FIG. **2**, the computer **101** may be programmed to display a facial image **120** on the display **105** of the computer monitor **104** and present facial movement indications **121** on the areas of the facial image **120** which correspond to areas of muscle movement in the face **107** of the subject **106** in real time as sensed by the electrodes **110**, as was heretofore described with respect to FIG. **1**. The information that is revealed by the facial movement indications **121** on the facial image **120** and by the data received from the oculography glasses **132** may be used for diagnostic, therapeutic and/or other purposes. Additionally or alternatively, the computer **101** may be programmed to electrically stimulate the muscles in the face **107** of the subject **106** via the electrodes **110** for diagnostic, therapeutic and/or other purposes, as was heretofore described.

Referring next to FIG. **5** of the drawings, an alternative illustrative embodiment of the facial movement measurement and stimulation apparatus is generally indicated by reference numeral **140**. The apparatus **140** may include a video game console **141** which may be adapted to receive one of various types of video game cartridges **142** for the playing of video games on a display **144** connected to the video game console **141**. A joystick **143** may be connected to the video game console **142** to facilitate the movement of video game characters (not illustrated) on the display **144** as the video game is played. Electrodes **110** may interface with the video game console **141** via electrode wiring **111**, as illustrated in FIG. **5**, or alternatively, via wireless transmissions **130** (FIG. **3**). The electrodes **110** are adapted for placement at various areas on the face **107** of a subject **106** either with or without the mask **116**.

In some applications, the electrodes **110** may function as facial movement sensors which are adapted to sense facial movements or expressions of the subject **106** by measuring typically voluntary, nerve-induced electrical stimulation of the various muscles in the face **107** of the subject **106**. The electrodes **110** may transmit electrical signals that correspond to the locations and intensities of the typically voluntary nerve-induced electrical stimulation of the facial muscles of the subject **106** to the video game console **141**. The video game console **141** may be adapted to utilize the electrical signals from the electrodes **110** as audio components and/or as visual components of a video game on the display **144** as the video game is played by the subject **106** or by another. The facial movements or expressions of the subject **106** may be used to control one or more aspects or characters of the video game. In some applications, the video game console **141** may be adapted to transfer electrical impulses to the electrodes **110** to effect various facial movements in the face **107** of the subject **106** via electrical stimulation of the facial muscles. The facial movements which are induced in the face **107** of the subject **106** via the electrical impulses may correspond to facial or other movements which are made by a character presented on the display **144** as a video game is being played.

Referring next to FIG. **6** of the drawings, a flow diagram of an illustrative embodiment of a facial movement measurement method is generally indicated by reference numeral **600**. In block **602**, facial movement sensors are provided. In some applications, the facial movement sensors may be electrodes. In some applications, the facial movement sensors may be accelerometers. In block **604**, a facial movement measuring and indicating device is provided. In block **606**, the facial movement sensors are connected to the facial movement measuring and indicating device. In block **608**, the facial movement sensors are placed on or surgically implanted in the face of a subject. In block **610**, outputs of the facial movement sensors in the form of electrical signals are measured. In block **612**, the outputs of the facial movement sensors may be indicated on a facial image in the form of facial movement indications provided on a display. In block **614**, the outputs of the facial movement sensors may be used for diagnostic, therapeutic and/or other purposes.

Referring next to FIG. **7** of the drawings, a flow diagram of an illustrative embodiment of a facial movement stimulation method is generally indicated by reference numeral **700**. In block **702**, electrodes are provided. In block **704**, an electrical input device is provided. In block **706**, the electrodes are connected to the electrical input device. In block **708**, the electrodes are placed on or surgically implanted in the face of a subject. In block **710**, electrical impulses are provided to the electrodes by transmitting an electrical current from the electrical input device to the electrodes. In block **712**, the response of the facial muscles of the subject to the electrical impulses may be used for diagnostic, therapeutic and/or other purposes.

Referring next to FIG. **8** of the drawings, a flow diagram of an illustrative embodiment of a facial movement stimulation method in which facial movements or expressions are transferred from a first subject to a second subject is generally indicated by reference numeral **800**. In block **802**, facial movement sensors are provided. In some applications, the facial movement sensors may be electrodes. In some applications, the facial movement sensors may be accelerometers. In block **804**, electrodes are provided. In block **806**, a stimulus transfer device is provided. In block **808**, the facial movement sensors and the electrodes are connected to the stimulus transfer device. In block **810**, the facial movement sensors are placed on or surgically implanted in the face of a first subject. In block **812**, the electrodes are placed on or surgically implanted in the face of a second subject. In block **814**, the output of the facial movement sensors, which may be in the form of electrical signals, is transferred to the stimulus transfer device. In block **816**, the output of the facial movement sensors may be measured. In block **818**, the output of the facial movement sensors may be transferred from the stimulus transfer device to the electrodes in the form of electrical impulses to effect the same facial movements or expressions in the second subject, as were made by the first subject.

Referring next to FIG. **9** of the drawings, a flow diagram of an illustrative embodiment of a therapeutic facial movement stimulation method is generally indicated by reference numeral **900**. In block **902**, electrodes are provided. In block **904**, an electrical stimulus device is provided. In block **906**, the electrodes are connected to the electrical stimulus device. In block **908**, the electrodes are placed on or surgically implanted in the face of a subject. In block **910**, a therapy program is selected. In block **912**, the electrical stimulus device is operated according to the selected therapy program to induce facial movements or expressions in the subject for therapeutic purposes. In some applications, the selected therapy program may be preprogrammed into a computer which may then automatically cycle through the electrical stimuli induced in the face of the subject to implement the therapy.

Referring next to FIG. **10**, a flow diagram of an illustrative embodiment of a facial movement measurement method in which facial movements of a subject are utilized in a video game is generally indicated by reference numeral **1000**. In block **1002**, facial movement sensors are provided. In some applications, the facial movement sensors may be electrodes. In some applications, the facial movement sensors may be accelerometers. In block **1004**, a video game console connected to a display is provided. In block **1006**, the facial movement sensors are connected to the video game console. In block **1008**, the facial movement sensors are placed on or surgically implanted in the face of a subject. In block **1010**, the output of the facial movement sensors may be measured. In block **1012**, the output of the facial movement sensors may be utilized as an audio and/or visual component of a video game that is played using the video game console.

Referring next to FIG. **11**, a flow diagram of an illustrative embodiment of the facial movement stimulation method in which electrical stimuli from a video game are transferred to a subject to effect facial movements in the subject is generally indicated by reference numeral **1100**. In block **1102**, electrodes are provided. In block **1104**, a video game console connected to a display is provided. In block **1106**, the electrodes are connected to the video game console. In block **1108**, the electrodes are placed on or surgically implanted in the face of a subject. In block **1110**, electrical impulses are transferred from the video game console to the electrodes to induce facial movements or expressions in the subject. The facial movements or expressions which are induced in the face of the subject may correspond to facial or other movements or expressions which are made by a character presented on the display as a video game is being played using the video game console. In some applications, the facial movements or expressions of the subject may be used to control one or more aspects of the video game.

Referring now primarily to FIGS. **12** and **13**, an example wearable computing system **200** is presented. The system **200** is shown in the form of eyeglasses **250**. The eyeglasses **250** include a lens element **258** and a frame **252** with side arms **254**, **256** extending therefrom. A body **260** of the eyeglasses **250** can be attached to, affixed to, or integrated into the frame **252**. The body **260** can be adapted as a computing system housing **260**, for housing computing system components, such as a computer **201**, a sensor **210**, a projector **208**, a camera **209**, and a user interface, such as a finger-operable touch pad **203**, as will be described in more detail below.

The frame **252** and extending side arms **254**, **256** are configured to secure the eyeglasses **250** to a first user's face **307**. When the eyeglasses **250** are worn by a first user **306**, the frame **252** can rest on the first user's forehead **317**. The side arms **254**, **256** are each projections that extend outwardly, away from the lens element **258** and can be positioned behind the first user's ears **318** to secure the eyeglasses **250** to the user's face **307**. The frame **252** and side arms **254**, **256** can be formed of a solid rigid polymer, plastic, and/or metal structure, or can be formed as a hollow structure of similar material to allow for wiring and interconnection of internal electrical components throughout the eyeglasses **250**.

As explained above, the system **200** can include on-board computing components, such as the computer **200**, sensors **210**, projector **208**, camera **209**, and the finger-operable touch pad **203**. The on-board computing components are shown positioned within the housing **260** attached to the extending side arm **254** of the eyeglasses **250**; however, it is understood that any one of or a multitude of the computing components may be provided on other parts of the eyeglasses **250** or can be remotely positioned, being in wireless or wired communication via a communication link **234** with the eyeglasses **250**. The computer **201** can include a processor **215**, memory, and/or storage **202**, as illustrated in FIG. **14**. The computer **201** can be configured to receive facial movement data from sensors **210** and/or the camera **209** and/or the computer **201** can be configured to receive user input commands associated with facial movement stimulation and measurement via the touch pad **203** and/or other user input devices, which data can be processed by the processor **215** and images generated for output onto the lens element **258**.

Still referring primarily to FIGS. **12** and **13**, the camera **209** is shown positioned on the front face of the body **260** of the eyeglasses **250**; however, it is understood that the camera can be provided on other parts of the eyeglasses **250**. The camera **209** is configured to capture still images as well as video. Although FIG. **12** illustrates a single camera **209**, it is understood that more than one camera **209** can be included in the system **200**. The camera **209** can face forward to capture still images and video of at least a portion of a real world view as perceived by the user **306** wearing the eyeglasses **250**. Additionally, the camera **209**, or a plurality of cameras (not shown), can be directed toward the user's face **307**. The cameras **209** can be configured to capture still images and video of the user's face **307** in order to collect facial movement data of a wearer **306** over a predetermine amount of time to be stored and/or utilized by the wearable computing system **200** or other device **280** that is remotely located. A multitude of still images and/or video of the face **307** can be stored and

compared by the computer **201** in order to produce a value corresponding to facial movement measurement of the user's face **307**, as measured by the cameras **209**.

The sensor **210** is shown positioned within the housing **260** attached to the extending side arm **254** of the eyeglasses **250**; however, it is understood that the sensor **210** may be provided on other parts of the eyeglasses **250**. Although FIG. **12** illustrates a single sensor **210**, it is understood that more than one sensor **210** or a plurality of sensors **210** formed as an array of sensors **210** can be included in the system **200**. The sensor **210** can be an electrode, accelerometer (as described above), or other sensor **210** well-known in the art. As described above with respect to the electrode and accelerometer, the sensor **210** (or electrode or accelerometer) can be adapted to provide electrical stimulation as well as to measure electrical nerve stimulation of the muscles of the face **307**. The sensor **210** can be provided on the eyeglasses **250** to contact the first user's face **307** when worn, so as to be in electrically-conductive communication with the first user's **306** facial muscles. There are various anatomical facial zones that can contact the eyeglasses **250** when worn on the user's face **307**, such as the glabellar, zygomatic, lateral canthal, and nasal zone, which are known in the art. An array of sensors **210** are preferably mounted on the eyeglasses **250** at locations corresponding to the zones, such that when eyeglasses **250** are worn by the user **306**, the array of sensors **210** are in direct contact with the skin of the face **307**, under which facial muscles lie within the zones (not shown).

Still referring primarily to FIGS. **12** and **13**, the sensor **210** can also be located remotely with respect to the eyeglasses **250**. For example, as best illustrated in FIG. **13**, the sensor **210** can be attached to a second user's face **207**, being in wired or wireless communication via a communication link **230** with the eyeglasses **250** secured to the first user's face **307**. The sensors **210** can be directly attached to the second user's face **207** using a suitable adhesive or can be integrated into a flexible mask **216** adapted to conform to the features of the face **207**. The flexible mask **216** may be separate from and remotely located with respect to the eyeglasses **250**, as illustrated in FIG. **13**, or the flexible mask **216** may be attached to or extend from the eyeglasses **250** (not shown). The first user **306** can be, for example, a physician attending to or monitoring the second user **206**, who can be, for example, a facial paralysis patient requiring supervised facial muscle nerve stimulation and corresponding facial muscle measurement data collection.

The finger-operable touch pad **203** is shown mounted on the extending side arm **254** of the eyeglasses **250**; however, it is understood that the touch pad **203** may be provided on other parts of the eyeglasses **250**. The touch pad **203** can detect at least one of a position, pressure, and a movement of a finger via apparatuses and methods well-known in the art, such as capacitive sensing, resistance sensing, and the like. The touch pad **203** can facilitate user input. For example, the user **306** may tap the touch pad **203** with his or her finger to initiate facial electrical nerve stimulation via an array of electrodes **110** mounted on the eyeglasses **250** (not shown). The computer **201** may receive the finger tap input command, process the input, and command the electrode to generate an electrical impulse sufficient to stimulate facial muscle nerves. Additionally, other user input devices may be integrated into the system **200**, such as a microphone, keyboard, and/or pointing devices (not shown).

The lens element **258** can be sufficiently transparent to allow the user **306** to see through the lens element **258**, as is traditionally provided for non-computing eyeglasses. The lens element **258** may additionally act as a display element, which is normally provided with traditional computing systems. For example, the projector **206** can be coupled to an interior surface of the body **260** of the eyeglasses **250**. The projector **206** can be configured to project an image **120** onto an exterior surface **259** (FIG. **15**) of the lens element **258**. The lens element **258** can also act as a light-projection system and can include a reflective coating, which reflects light projected onto the lens element **258** from the projector **206**. Alternatively, the projector **206** can be a scanning laser device that interacts directly with the user's **306** retina. Although, FIG. **12** shows only one lens element **258** and one projector **208**, it is understood that the system **200** may include two or more lens elements **258** and projectors **208**. The lens elements **258** can include a transparent or semi-transparent display surface **259**, such as a light emitting diode (LED) display, a liquid crystal display (LCD), and the like. It is understood that any display surface can be implemented, provided that it allows the eyeglass wearer **306** to view images displayed thereon.

Referring now primarily to FIG. **14**, an example schematic diagram of a computer network infrastructure is illustrated. In an example network **270**, a device, such as the wearable computing system **200**, is adapted to communicate, via the communication link **230** (e.g. a wired or wireless connection), with the sensor **210**, which may be an electrode, accelerometer, or other known sensor, as described with reference to FIGS. **12** and **13**. Additionally, the wearable computing system **200** is adapted to communicate, via the communication link **234** (e.g. a wired or wireless connection), with a remote device **280**.

Referring primarily to FIGS. **13** and **14**, the sensor **210** can transmit an electrical impulse effective to contract a muscle in the user's face **207**, **307** via the communication link **230**. The sensor **210** can also detect and/or measure nerve-induced electrical stimulation of the muscle in the user's face **207**, **307** and transmit the detected and/or measured data corresponding to the nerve-induced electrical stimulation to the computing system **200** via the communication link **230**. The data can be stored in storage **202**, processed by the processor **215**, and the processed data displayed on a display **204** of the wearable computing system **200**, as will be described below with reference to FIG. **15**.

The system **200** includes the computer **201**, having the processor **215**, memory and/or non-volatile storage **202**, and a wireless communication interface **213**. The display **204** and camera **209** are connected to the computer **201**. The processor **215** can be any type of processor, such as a microprocessor or a digital signal processor, for example. The processor **215** with supporting software can be adapted to transmit electrical impulses to the sensors **210**, such as electrodes **110**, through wiring or a wireless network **230**, in such a pattern and with such intensity as to electrically stimulate and contract musculature in the face **307** and induce desired facial movements or expressions in the face **307**. The processor **215** can also be adapted to receive and store electrical signals that correspond to voluntary and involuntary nerve-induced electrical stimulation of the musculature received by the sensors **210**. The processor **215** can store such facial movement measurements in storage **202**. Additionally, software, such as the software configured to process and utilize facial movement data, can be stored in storage **202**.

The wireless communication interface **213** can include one or more network interface cards (NIC) that can provide the capability for the wearable computing system **200** to network with, for example, a personal area network (PAN), such as a Bluetooth® network, a local area network (LAN), such as a Wi-Fi network, or a wide area network (WAN), such as a

cellular mobile communications network, for example. The communication links **230**, **234** can be wired or wireless.

The remove device **280** can be another computing device, such as a personal computer **101** (FIG. **1**), a laptop, a computer tablet, a cellular telephone, a handheld device, a video game console **141** (FIG. **5**), or the like, that is configured to receive facial movement data from and transmit facial movement data to the wearable computing system **200** via the communication link **230**.

An example provided image **120** being displayed on the exemplary display **258** is illustrated in FIG. **15**. In particular, the example illustrates the facial image **120** including facial movement indications **121** described above with reference to FIG. **2** being displayed on the computer monitor **104**, except that the image **120** is displayed on the display surface **259** of the display **258** of the wearable computing device **200** in FIG. **15**, rather than the personal computer monitor **104** of FIG. **2**. It is understood that facial movement data can also be displayed on the display **258** in other formats, such as a table **122** or spreadsheet format, for example, listing numerical data corresponding to facial movement output signals.

Exemplary methods involving a wearable computing system, such as **200**, and stimulation and measurement of facial muscle movement utilizing the wearable computing system is presented in FIGS. **16** and **17**. Although FIGS. **16-17** show a specific order of executing functional logic blocks, the order of executing the blocks may be changed relative to the order shown. Also, two or more blocks shown in succession may be executed concurrently or with partial concurrence. Certain blocks may also be omitted for the sake of brevity. And some blocks are merely exemplary steps in an exemplary implementation, but are not required in order to be in accordance with the present invention.

Referring now primarily to FIG. **16**, a flow chart illustrating a method according to an exemplary embodiment in which facial movement data is received, stored, and displayed by the wearable computing device **200** is generally indicated by reference numeral **1200**. More specifically, in block **1202**, a wearable computing system is provided. The wearable computing system may be in the form of eyeglasses, a mask, contact lenses, and the like. In block **1204**, a facial movement sensor, such as for example, an electrode, a camera, or an accelerometer is provided. In block **1206**, the wearable computing system can receive an input command associated with commanding facial movement sensors that may be mounted on the wearable computing system or may be remotely located. The input command may be an input from a user input interface, such as a touch pad or microphone, and the command may be a command for the facial movement sensors to transmit an electrical impulse to provide facial movement stimulation to a user's facial muscles. In block **1208**, based on the received input command, the wearable computing system transmits a command to facial movement sensors to provide facial movement stimulation to the user's facial muscles. In block **1210**, the wearable computing system receives facial movement data from facial movement sensors, which data corresponds to nerve-induced electrical stimulation of facial muscles. The facial movement data can be received by a processor of the wearable computing system over a wired or wireless network. In block **1212**, the wearable computing system stores facial movement data in non-volatile or non-transitory storage. In block **1214**, the wearable computing system displays an image corresponding to nerve-induced electrical stimulation of facial muscles on a display of the wearable computing system.

Referring now primarily to FIG. **17**, a flow chart illustrating a method according to an exemplary embodiment in which facial movement measurement data received by a wearable computing device is generally indicated by reference number **1300**. More specifically, in block **1302**, a wearable computing device is provided. The wearable computing device may be in the form of eyeglasses, a mask, contact lenses, and the like. In block **1304**, the wearable computing device receives facial movement measurement data from facial movement sensors that may be mounted on the wearable computing device or may be remotely located with respect to the wearable computing device. The facial movement measurement data may be in the form of, for example, electrical output signals from an electrode, accelerometer or other sensor, corresponding to electrical stimulation of the facial muscles. Alternatively, the facial movement data may be muscular activity measured by a camera of the wearable computing device, as described above. In block **1306**, an executable instruction set stored in non-volatile or non-transitory storage on the wearable computing device is provided. The instruction set can be a software application that is adapted to receive facial movement data as a control input. For example, the software application may be an executable instruction set for a video game adapted to utilize and command the output of the facial movement sensors (e.g. electrode, accelerometer, camera, etc.) to control one or more aspects or characters of the video game, as described above with reference to FIG. **5**. For example, electrical impulses transferred from the video game software to electrodes to induce facial movement may correspond to facial movements or expressions, which are made by a character presented on the display associated with the video game. As another example, the output of the facial movement sensors may be utilized as an audio and/or visual component of the video game. In block **1308**, the wearable computing device transmits the electrical output signals from the facial movement sensors to the software application as an input command. In block **1310**, an aspect of the software application is controlled in accordance with the electrical output signals from the facial movement sensors.

It will be appreciated by those skilled in the art that the apparatus and method in the various embodiments described herein above have numerous potential applications beyond those which are expressly described herein. For example, the apparatus and method may be used to study the contagiousness of emotions or the effect which changing facial expressions have on emotions in human subjects. In some applications, the apparatus and method may be used in mood intervention scenarios in which facial expressions that are indicative of positive emotions are transferred from one subject to another subject. The apparatus and method may be used as a polygraph in which facial twitches and movements may indicate whether a subject is lying in response to questioning. In some embodiments, the apparatus may be constructed with non-magnetic parts for use in conjunction with an MRI or other medical device.

Since many modifications, variations, and changes in detail can be made to the described preferred embodiments of the invention, it is intended that all matters in the foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense. Thus, the scope of the invention should be determined by the appended claims and their legal equivalence.

What is claimed is:

1. A wearable computing system, comprising:

eyeglasses, comprising:

a lens element including a display,

a frame with side arms extending therefrom, and

an eyeglasses body adapted to function as a computing system housing, the computer system housing comprising a computer having a processor, storage, and a wireless communication device; and

at least one sensor adapted to measure facial muscle movement in a user, the at least one sensor in electrical communication with the computer,

wherein the at least one sensor is an electrode in electrically conductive communication with a facial muscle of the user and is adapted to transmit an electrical impulse to the facial muscle of the user to electrically stimulate the facial muscle.

2. The wearable computing system as recited in claim **1**, wherein the at least one sensor is a camera having a camera lens, wherein the camera is mounted on the eyeglasses such that when the eyeglasses are worn by the user, the camera lens is directed toward the user's face and is configured to capture at least one of a still image and video of the face and wherein the processor is configured to receive and compare captured images and video and generate facial movement measurement data therefrom.

3. The wearable computing system as recited in claim **2**, wherein the computer is adapted to output facial muscle movement signals indicative of facial muscle movement of the user to the display of the eyeglasses.

4. The wearable computing system as recited in claim **1**, further comprising a mask, wherein the at least one electrode comprises a plurality of electrodes that are carried by the mask.

5. The wearable computing system as recited in claim **4**, wherein the mask extends from the eyeglasses.

6. The wearable computing system as recited in claim **4**, wherein the plurality of electrodes are located at each of a top portion, a middle portion, and a bottom portion of the face, wherein the top portion, corresponds to the user's forehead area, and wherein the middle portion corresponds to the user's eye and nose area, and wherein the bottom portion corresponds to the user's mouth area.

7. The wearable computing system as recited in claim **1**, wherein the at least one electrode comprises a plurality of electrodes mounted on the eyeglasses such that when the eyeglasses are worn by the user, the plurality of electrodes are in electrically conductive communication with the user's facial muscles.

8. The wearable computing system as recited in claim **7**, wherein the computer is adapted to output facial muscle movement signals indicative of facial muscle movement of the user to the display of the eyeglasses.

9. The wearable computing system as recited in claim **7**, further comprising an instruction set stored in computer storage corresponding to video game software.

10. The wearable computing system as recited in claim **9**, wherein the electrical impulse corresponds to a movement of a video game character presented on the display.

11. A method of measuring and indicating facial movement of a user, comprising steps of:

providing a wearable computing device having a processor, storage, a user input, and a display;

providing at least one facial movement sensor mounted on the wearable computing device such that the at least on facial movement sensor is directed toward the user's face when the wearable computing system is worn by the user;

receiving an input command from the user input commanding the at least one facial movement sensor to transmit an electrical impulse to provide facial movement stimulation to the user's facial muscles;

transmitting the command to the at least one facial movement sensor;

receiving facial movement measurement data from the at least one facial movement sensor, which data corresponds to nerve-induced electrical stimulation of the user's facial muscles;

storing facial movement measurement data in storage; and

displaying an image corresponding to nerve-induced electrical stimulation of facial muscles on the display of the wearable computing device.

12. The method of measuring and indicating facial movement in a user as recited in claim **11**, wherein the providing the wearable computing system comprises providing a wearable computing system in the form of one of a group of eyeglasses, a mask, and contact lenses.

13. The method of measuring and indicating facial movement in a user as recited in claim **12**, wherein the providing at least one facial movement sensor comprises providing a camera having a camera lens directed toward the user's face.

14. The method of measuring and indicating facial movement in a user as recited in claim **13**, further comprising:

the camera capturing at least one of a still image and video of the face,

comparing captured images and video of the face, and

generating facial movement measurement data therefrom.

15. The method of measuring and indicating facial movement in a user as recited in claim **12**, wherein the providing at least one facial movement sensor comprises providing a plurality of electrodes in electrically conductive communication with facial muscles of the user.

16. The method of measuring and indicating facial movement in a user as recited in claim **15**, further comprising transmitting an electrical impulse to facial muscles of the user to electrically stimulate the user's facial muscles.

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